

CLAIMS

What is claimed is:

1. A method for developing a resist film formed on a substrate, the method comprising the steps of:
 - applying a surfactant-containing liquid onto the resist film;
 - displacing the surfactant-containing liquid film with a developing
 - 5 solution of selected concentration; and
 - developing the resist film using the developing solution.
2. The method as claimed in claim 1, the method further comprising:
 - determining a concentration for the surfactant-containing liquid based
 - on one or more characteristics of the resist film.
3. The method as claimed in claim 1, wherein the surfactant-containing liquid comprises at least one of an ionic surfactant, a nonionic surfactant, an anionic surfactant, and a cationic surfactant.
4. The method as claimed in claim 1, the method further comprising:
 - determining a concentration for the surfactant-containing liquid based
 - on the resist film and selecting the concentration for the developing solution
 - based on one or more characteristics of the surfactant-containing liquid and
 - 5 the resist film.
5. The method as claimed in claim 1, the method further comprising:
 - determining a contact angle for the developing solution on the resist
 - film; and
 - determining a concentration for the surfactant-containing liquid
 - 5 effective to achieve a decrease in the contact angle.

6. The method as claimed in claim 1, the method further comprising:
prior to applying the surfactant-containing liquid, transferring the
substrate having the resist film thereon into a developing unit; and
positioning the substrate on a spin chuck,
5 wherein the applying and displacing are performed while rotating the
spin chuck.

7. The method as claimed in claim 6, wherein the developing includes
allowing the developing solution to stand on the resist film for a prescribed
time sufficient to permit a developing reaction to proceed, and wherein the
method further comprises:
5 after the developing, rinsing the substrate while rotating the spin chuck.

8. The method as claimed in claim 7, the method further comprising:
after the rinsing, drying the substrate while rotating the spin chuck; and
transferring the substrate out of the developing unit.

9. The method as claimed in claim 1, wherein an exposed portion and
an unexposed portion of the resist film have a difference in solubility, the
method further comprising:
determining a concentration for the surfactant-containing liquid based
5 on at least one of the solubility of the exposed portion of the resist film and
solubility of the unexposed portion of the resist film.

10. The method as claimed in claim 1, the method further comprising:
determining a concentration for the surfactant-containing liquid based
on the water solubility of the resist film.

11. The method as claimed in claim 1, further comprising rotating the
substrate during the step of applying, and wherein the step of applying a
surfactant-containing liquid onto the resist film is carried out by using a nozzle
capable of depositing the surfactant-containing liquid in a substantially circular
5 shape, the nozzle being positioned over the center of the substrate while
depositing the surfactant-containing liquid onto the rotating substrate.

12. The method as claimed in claim 1, wherein the step of applying a surfactant-containing liquid onto the resist film is carried out by using a nozzle capable of depositing the surfactant-containing liquid in substantially a band shape, the nozzle being scanned over the substrate while depositing the surfactant-containing liquid.

13. The method as claimed in claim 1, wherein the step of applying a surfactant-containing liquid onto the resist film is carried out by using a plurality of nozzles each capable of depositing the surfactant-containing liquid in substantially a band shape, the plurality of nozzles being scanned over the substrate while depositing the surfactant-containing liquid.

14. The method as claimed in claim 1, further comprising rotating the substrate during the step of displacing, and wherein the step of displacing the surfactant-containing liquid with a developing solution is carried out by using a nozzle capable of depositing the developing solution in a substantially circular shape, the nozzle being positioned over the center of the substrate while depositing the developing solution onto the rotating substrate.

15. The method as claimed in claim 1, wherein the step of displacing the surfactant-containing liquid with a developing solution is carried out using a nozzle capable of depositing the developing solution in a substantially band shape, the nozzle being scanned over the substrate while depositing the developing solution.

16. The method as claimed in claim 1, wherein the step of displacing the surfactant-containing liquid with a developing solution is carried out by using a plurality of nozzles each capable of depositing the concentration-adjusted developing solution in substantially a band shape, the plurality of nozzles being scanned over the substrate while depositing the developing solution.

17. The method as claimed in claim 1, wherein the step of applying a surfactant-containing liquid onto the resist film is carried out by using a nozzle capable of depositing the surfactant-containing liquid in dropwise fashion, the nozzle being positioned over the center of the substrate while depositing at least one drop of the surfactant-containing liquid onto the substrate while rotating the substrate.

18. The method as claimed in claim 1, the method further comprising:
selecting the concentration of the developing solution in accordance with one or more characteristics of the surfactant-containing liquid and the resist film.

19. The method as claimed in claim 1, wherein the developing includes rotating the substrate having the developing solution supplied thereto for a prescribed time sufficient to permit a developing reaction to proceed.

20. A method for processing of a resist film formed on a substrate, the method comprising the steps of:

depositing a resist film on the substrate;

5 applying a surfactant-containing liquid onto the resist film, wherein the surfactant-containing liquid is chosen based on one or more characteristics of the resist film;

selecting a concentration of a developing solution in accordance with one or more characteristics of the surfactant-containing liquid and the resist film;

10 supplying the developing solution onto the resist film after applying the surfactant-containing liquid on the substrate;

developing the resist film by allowing the substrate having the developing solution supplied thereto to stand for a prescribed time sufficient to permit a developing reaction to proceed; and

15 thereafter, rinsing the substrate.

21. The method as claimed in claim 20, wherein the surfactant-containing liquid comprises at least one of an ionic surfactant, a nonionic surfactant, an anionic surfactant, and a cationic surfactant.

22. The method as claimed in claim 20, the method further comprising: determining a concentration for the surfactant-containing liquid based on the resist film thickness.

23. The method as claimed in claim 20, the method further comprising: determining a concentration for the surfactant-containing liquid based on the resist film and one or more characteristics of selecting the concentration of the developing solution based on the concentration of the surfactant-containing liquid.

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24. The method as claimed in claim 20, the method further comprising:
determining a concentration for the surfactant-containing liquid based
on the water solubility of the resist film.

25. The method as claimed in claim 20, the method further comprising:
determining a contact angle for the developing solution on the resist
film; and

5 determining a concentration for the surfactant-containing liquid
effective to achieve a decrease in the contact angle.

26. The method as claimed in claim 20, the method further comprising:
prior to applying the surfactant-containing liquid, transferring the
substrate having the resist film thereon into a developing unit; and

5 positioning the substrate on a spin chuck,
wherein the applying and supplying are performed while rotating the
spin chuck.

27. The method as claimed in claim 26, the method further comprising:
after the rinsing, drying the substrate while rotating the spin chuck; and
transferring the substrate out of the developing unit.

28. The method as claimed in claim 20, further comprising rotating the
substrate during the step of applying, and wherein the step of applying a
surfactant-containing liquid onto the resist film is carried out by using a nozzle
capable of depositing the surfactant-containing liquid in a substantially circular
5 shape, the nozzle being positioned over the center of the substrate while
depositing the surfactant-containing liquid onto the rotating substrate.

29. The method as claimed in claim 20, wherein the step of applying a
surfactant-containing liquid onto the resist film is carried out by using a nozzle
capable of depositing the surfactant-containing liquid in substantially a band
shape, the nozzle being scanned over the substrate while depositing the
5 surfactant-containing liquid.

30. The method as claimed in claim 20, wherein the step of applying a surfactant-containing liquid onto the resist film is carried out by using a plurality of nozzles each capable of depositing the surfactant-containing liquid in substantially a band shape, the plurality of nozzles being scanned over the substrate while depositing the surfactant-containing liquid.

31. The method as claimed in claim 20, further comprising rotating the substrate during the step of supplying, and wherein the step of supplying the developing solution onto the resist film is carried out by using a nozzle capable of depositing the developing solution in a substantially circular shape, the nozzle being positioned over the center of the substrate while depositing the surfactant-containing liquid onto a rotating substrate.

32. The method as claimed in claim 20, wherein the step of supplying the developing solution onto the resist film is carried out by using a nozzle capable of depositing the developing solution in a substantially band shape, the nozzle being scanned over the substrate while depositing the developing solution.

33. The method as claimed in claim 20, wherein the step of supplying the developing solution onto the resist film is carried out by using a plurality of nozzles each capable of depositing the developing solution in substantially a band shape, the plurality of nozzles being scanned over the substrate while depositing the developing solution.

34. The method as claimed in claim 20, wherein the step of applying a surfactant-containing liquid onto the resist film is carried out by using a nozzle capable of depositing the surfactant-containing liquid in dropwise fashion, the nozzle being positioned over the center of the substrate while depositing at least one drop of the surfactant-containing liquid onto the substrate while rotating the substrate.

35. The method as claimed in claim 20, wherein the substrate having the developing solution supplied thereto is rotated for at least a portion of the prescribed time.

36. An apparatus for supplying a liquid onto a substrate, comprising:
- a spin chuck for supporting and rotating a substrate thereon;
 - a first nozzle having a circular shape and serving to deposit a surfactant-containing liquid in substantially a circular shape onto the substrate
- 5 positioned on the spin chuck;
- a surfactant-containing liquid supply for supplying the surfactant-containing liquid having a prescribed concentration to the first nozzle;
 - a second nozzle having a circular shape and serving to deposit a developing solution in substantially a circular shape onto the substrate
- 10 positioned on the spin chuck; and
- a developing solution supply for supplying a developing solution having a prescribed concentration into the second nozzle, wherein the first nozzle and the second nozzle are adapted to separately dropwise deposit the surfactant-containing liquid and the developing solution onto the substrate
- 15 positioned on the spin chuck while rotating the spin chuck.